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ABSTRACT

The Construction Systems Program (CSP) is the management process utilized in the construction of additions to four schools in the Detroit School District. The objectives of CSP were (1) to reduce the time required to plan and construct new buildings and additions, (2) to reduce the cost of new buildings and additions, and (3) to maintain or improve the quality of new buildings and additions. This program assessment provides information to aid the members of the Detroit Board of Education in making decisions about future commitments to systems management and systems construction in the building programs. The first part, the introduction, covers term definitions and provides a list of project planners and a report overview. The second, or background section, deals with goals developed by citizens for the School Housing Division and goals for CSP, and describes the organization necessary to goal accomplishment. In the third section, procedures and management, the critical steps taken for the establishment of program direction and the management of the CSP project are discussed. The last section, project outcomes, describes CSP schools and assesses the effectiveness of CSP in relation to the time and cost objectives. A related document is EA 004 753. (Author/MLF)

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AN ASSESSMENT

OF

THE DETROIT PUBLIC SCHOOLS

CONSTRUCTION SYSTEMS PROGRAM

EA 004 815

Prepared for: The Members of the Board of Education,
The City of Detroit

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R. L. Featherstone

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CSP-1

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

CSP-1 was a pilot program designed by the CSP staff with advice from the Advisory Committee. As a pilot program of experimental nature, constraints and conditions not ordinarily met in such projects have had to be overcome. The fact that the projects were imposed on the architects made the situation less than ideal. However, in spite of the conditions, the cooperation of all disciplines has been exceptional.

The objectives of the Construction Systems Program (CSP) were (1) to reduce the time required to plan and construct new buildings and additions, (2) to reduce the cost of new buildings and additions (when compared with traditional construction), and (3) to maintain or improve the quality of new buildings and additions.

The CSP objectives have been achieved. The results have been cost savings over conventional techniques and a major reduction in construction time. The new additions are complete except for a few minor corrections. The alteration work in the older units is complete with the exception of a few rooms where, as anticipated, student occupancy delayed contractor access. The facilities being provided by this

project are to be of high quality and are to possess adaptability to respond to changing educational program needs.

Savings in Construction Time

The construction contracts for the four CSP-1 additions were awarded in three stages from March, 1971, to August, 1971. The target date for completion of construction had been set for May of 1972. Construction of the four additions was essentially completed in July and August, 1972. While the one-year construction period was overshot by two to three months, the average of 14.2 months construction time compares very favorably with the average construction time of 24.4 months on other recent Detroit school projects of similar scope, bid and built in the conventional manner.

Savings in Building Cost

The building cost for the project's four additions was estimated at design manual stage to be $30.04 per square foot. The cost per square foot at bid time was $30.99. This cost figure is a sharp reduction from the average construction cost of $37.60* per square foot for school projects of similar scope built recently in Detroit with conventional methods. In fact, the savings on the project of approximately $6.61* per square foot by using the CSP-1 approach rather than the conventional approach equals a total construction savings of approximately $1,850,800.00. These cost figures do not

*Adjusted to 1971 costs.

reflect the fact that CSP-1 facilities will be air conditioned, while the buildings used in the comparison were not air conditioned. Since air conditioned space is more expensive, the amount saved could be larger than reported if a means of comparison could be achieved.

Maintenance or Improvement of Quality

A plausible approach to the question of quality may be through consideration of the prescribed and required environmental aspects of the CSP-1 buildings. The CSP-1 buildings are more flexible than recent conventional buildings. The relocatability of partitioning, lighting, and air supply and return make the CSP-1 more adaptable. Thus, when compared with many conventional buildings, the CSP-1 projects are likely to be more functional as educational programs and teaching methods change in the future. Further, acoustics, lighting, and air conditioning are maximized and should contribute to a quality learning environment.

Conclusions

The conclusions derived from the CSP-1 assessment are listed first, and are capitalized. The additional statements represent conclusions abstracted from literature and experience relating to predecessor programs, but reinforced by CSP-1 activities.

CSP-1 Conclusions

1. THE OBJECTIVE TO REDUCE THE TIME REQUIRED TO PLAN AND CONSTRUCT NEW ADDITIONS HAS BEEN REACHED.

2. THE OBJECTIVE TO REDUCE THE COSTS OF THE NEW ADDITIONS (WHEN COMPARED TO TRADITIONAL CONSTRUCTION) HAS BEEN REACHED.
3. THE OBJECTIVE TO MAINTAIN OR IMPROVE THE QUALITY OF THE NEW ADDITIONS WILL PROBABLY BE REACHED.
4. The utilization of a management contractor has served to expedite the CSP-1 construction phase, and such sustained management could benefit additional phases (programming, site acquisition, design, and equipping).
5. Rapid response by the owner during all phases of design and construction, including the authority for owner's staff to award contracts (within established budget limitations), is a vital aspect of project acceleration.
6. Available to school board owners is a variety of options for organizing and managing their construction programs for increased speed and economy. Options include such techniques as bulk bidding, phased bidding, performance specifications, industrialization, and systemization.
7. Not all buildings or groups of buildings lend themselves to the acceleration techniques, nor do the needs demand the concentrated effort required.
8. Most public schools built in the same geographic region have certain common elements (components) which lend themselves to repetition without the limitations of design standardization.
9. The same design and dimensional characteristics of component systemization which accelerate construction also

facilitate relocatability and flexibility, to the ultimate benefit of educational utilization.

10. Because of continuing escalation of building costs, techniques that overlap planning phases with construction phases will result in savings of both time and money.
11. Because of the particular escalation of on-site labor costs, techniques that increase industrialization (off-site fabrication of building components) will result in specific economies.
12. The ability of school board owners to respond quickly to community needs for school facilities may have societal benefits as well as economic advantages.
13. The various new techniques used in organizing and managing school construction programs result in modifications in the traditional roles of all participants in the building team (owner, architect, engineers, contractors, suppliers).
14. A compression of time in the design-bid-build sequence necessitates closer cooperation among all participants and, specifically, more intensive involvement by the owner.
15. Phased bidding increases the owner's hold on costs but adds somewhat to risk, increasing need for owner competence and administrative flexibility.
16. Despite changed roles, the participation of individual design professionals with specific projects continues

to have overall benefits in relating the user needs of the school and its community to the total design process.

17. Multiproject programs employing the services of more than one group of design professionals can result in qualitative upgrading of individual performance.
18. Through the experience and confidence gained by the participants, the cost/time efficiency factors can be expected to improve markedly in a subsequent program which utilizes some or all of the original building team members.
19. Intensive involvement of city and state coding officials and other regulatory agency personnel in the initial planning phases results in economies, fewer on-site construction delays, and greater latitude in certain aspects of building design.

Recommendations

Four major recommendations have been drawn from the material presented in this report. The recommendations are: The Detroit Board of Education should take the necessary action to:

1. Continue to develop, implement, and assess techniques of management science in the School Housing Division;
2. Request an analysis of future construction projects in order to decide which projects should be designated as construction systems projects;

3. Reaffirm and make applicable to future construction system projects its resolution relating to decision making, which was stated as follows:

   "Resolved that the Board of Education, with the approval of the design manuals for the four projects in the pilot systems program, authorize the School Housing Division to take bids and award contracts within the stated budget allocations for the projects." (September 22, 1970)

4. Designate, on future CSP projects and when recommended by the School Housing Division, a project construction manager to be retained as an agent of the Board of Education.

SECTION I

INTRODUCTION

> A systems approach to construction of School 124, an elementary "Minischool" in Baltimore's Brooklyn area, and its neighbor, School 304, was developed. . . . This approach was designed to save the Baltimore Board of Education time and money.[1]

The members of boards of education of North America's large cities face many complex problems. Among these problems are decisions that must be made about the use of funds for the construction of new facilities. The members of boards of education are pressured to replace antiquated buildings, to construct additional capacity buildings, and to accomplish the task immediately and at low cost. The members of the Detroit Board of Education are no exception. They must make decisions about future replacement and additional facilities, and they will be expected to make decisions that produce the "miracle" of quality educational buildings constructed in a minimum period of time and at an acceptable cost level. In order to aid the members of the Detroit Board of Education in the decision-making process, the following assessment of the development and progress of the Detroit

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[1] "Systems Approach Saves Time and Money," Facility Newsfront, American School & University (January, 1972), p. 8.

Construction Systems Program has been completed. The material presented in the report is an attempt to assess the current status of the management process and the products that are the major elements of the Detroit Construction Systems Program. The major purpose of the assessment is to provide information that will aid the members of the Detroit Board of Education in making decisions about future commitments to systems management and systems construction in the building programs. Throughout the report many terms are used that are not common, everyday vocabulary for most people. Therefore, appropriate definitions are important to the reader.

Definition of Terms[2]

1. Building Component.* A group of parts which forms a portion of a building subsystem; e.g., a door, its frame and hardware as part of a partitioning subsystem; the second subdivision of a building system.

2. Building Subsystem.* A group of building components that performs as specified; e.g., an HVC subsystem made up of components such as energy converters, air-handling units, ductwork, diffusers, and controls; the first subdivision of a building system.

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[2]The definitions of terms marked with an asterisk were taken from the Building Systems Planning Manual, published by Educational Facilities Laboratories in August, 1971.

3. Building Subsystem Performance Characteristics.* The actual characteristics of a given manufacturer's subsystem, as opposed to the needs established by the user.

4. Building Subsystem Performance Requirements (Criteria).* A set of statements of the essential characteristics that a building subsystem must provide in order to satisfy user needs.

5. Building System.* An assembly of building subsystems and components, and the rules for putting them together in a building. Normally these components are mass-produced and used for specific generic projects in a construction program.

6. CSP. The Detroit Construction Systems Program.

7. CSP-1. The pilot project in which four schools were grouped.[3]

8. Fast Track. Used synonymously with "phased bidding" and refers to limiting the scope and duration of bidding, thus reducing market uncertainties and accelerating response.

9. Goals. That which an organization wishes to achieve in the future. Usually a long-range, philosophical statement that is used to chart the future course of an organization.

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[3]Boynton Junior High, Cerveny Junior High, Cooley Senior High, and Sherrard Junior High (all additions to existing schools).

10. Objectives. Discrete, finite, measurable increments or steps taken by the organization in the process of "Achieving." Objectives can be measured at a specific point in time with appropriate instrumentation.

11. Performance Specification.* A set of specifications which describes a building system, subsystem, or component for bidding purposes, not by its physical materials, shapes, dimensions, or other physical properties, but by the desired results; in other words, not by what it is, but by what it does.

12. Planning Grid.* A reference grid, usually rectangular with the spacing of the grid lines determined by the module of the building system, which serves as a dimensional framework for organizing the building and/or the site plan.

13. System.* An interdependent group of items forming a unified whole.

14. Systems Approach.* Viewing a problem as a system, stressing the interrelation of problem elements and processes and the relation of the problem to its larger context.

15. Systems Building.* The application of the systems approach to construction, normally resulting in the organization of programming, planning, design, financing, manufacturing, construction, and evaluation of buildings under single or highly coordinated management into an efficient total process.

Project Planners

The Construction Systems Program (CSP) was created and developed by members of the Detroit School Housing Division under the direction of Dr. Alvin Skelly, Deputy Superintendent, and Mr. Bernard Coker, Assistant Superintendent. Mr. Ben Graves, of the Educational Facilities Laboratories, and Mr. Wallace Cleland, AIA, of the School Housing Division staff, working with Dr. Skelly, developed the original objectives and prepared the EFL proposals. Mr. Cleland has been the technical director of CSP and has had direct responsibility for supervision of the project.

Overview of Report

The report is presented in four sections. Section II may be termed background in nature. Section III is descriptive, and relates to procedures and management of the CSP-1 project. Section IV is an effort to provide comparative information (i.e., CSP-1 projects in relation to traditional construction projects).

SECTION II

BACKGROUND

CSP is part of a broad effort of boards of education and staff members, past and present, to provide appropriate educational facilities for the children of the City of Detroit. The following material is presented to show the linkage between previously established goals relating to the Detroit School Housing Division and the goals and objectives of the CSP. The material in Section II is presented in three categories: (1) goals developed by citizens to guide the Detroit School Housing Division, (2) goals and objectives of the CSP, and (3) CSP organization to accomplish goals.

Goals for the School Housing Division

Several documents[4] and some past board actions provide the basis for selected goal statements. A primary source and one that was formally adopted by Detroit Board of Education action was the Citizens Advisory Committee on Equal Educational

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[4] Citizens Advisory Committee on Equal Educational Opportunities (March, 1962), The Price of Excellence--An Inventory of Facility Needs in the Detroit Public Schools (November, 1962), and Citizens Advisory Committee on School Needs (November, 1958).

Opportunities.[5] In this report are several "principles" that are "goal-like" in statement. The principles are as follows:

Principle One: Any school building program should provide as a significant feature of its plan, facilities which are safe and healthful for all people who are to use them--students, teachers, and community.

Principle Two: The school building program should make provision for facilities which will foster the development of all aspects of the desired school program.

Principle Three: The school building program should provide adequate capacity in all types of facilities when needed and where needed throughout the school district.

Principle Four: The school building program should take into account the applicable portions of any community plant which has been developed; for example, the school building program should not include gymnasium, auditorium, etc. where these facilities are already provided for in part or in whole by other community agencies.

Principle Five: The school building program should avoid any discrimination against, or partisan treatment in favor of, any segment of the population or section of the school district.

Principle Six: The school building program should provide all needed school facilities at reasonable costs and within such limitation as cost provides.

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[5]Approved by board action on April 10, 1962.

Principle Seven: The school building program should make adequate provision for utilizing existing school structures within the overall plan for long-range school building facilities.

Principle Eight: The school building program should provide as an essential characteristic an integrated program with other involved community agencies such as the Department of Parks and Recreation and the Urban Renewal Program.

All of the principles point toward the achievement of quality school construction. Principle Three may be interpreted as having a "time-related element," since its reference is to capacity "when needed" as well as where needed in the district. Principle Six is directly related to costs and requires a dedication to "reasonable costs." These two selected principles became major guidelines for CSP.

Goals and Objectives of CSP

The goals and objectives of the CSP were extracted from the various reports and proposals prepared for the Board of Education and for Educational Facilities Laboratories.[6] Major statements that reflect goals for the CSP are listed below, and are quotes from one or more of the documents identified.

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[6]Detroit Board of Education reports entitled Supplementary School Space System (March, 1969; approved by the Board April 22, 1969), Completion of the Construction Systems Program (May, 1971), and Update of Supplemental Proposal to Educational Facilities Laboratories, Inc. (October, 1971; approved by the Board November 23, 1971).

The CSP has goals that are linked to those adopted as principles by the Detroit Board of Education.[7] It was expected that CSP would allow Detroit:

> To build new buildings more quickly and economically by taking advantage of the efficiency of modern industrial mass production (MAR 69-8).

Further, CSP would be:

> A building system that would offer:
>
> (1) speed of construction
> (2) long term reduction in costs
> (3) qualitative improvements in environment
> (4) architectural freedom of design
> (5) flexibility in planning that would encourage utilization of creative potential of a building by its users (MAR 69-8).

Moreover, CSP would accomplish the previously mentioned goals through:

> planning a building program of sufficient homogeneity to be adapted for repetitive elements, and of sufficient magnitude to merit the assembling of the technical-legal-managerial skills required to make it operable (MAR 69-12).

CSP is a program that, to be effective:

> . . . involves not only educators, but also a broad spectrum of the building industry in a constructive endeavor (MAR 69-13).

It was assumed that as a result of the CSP,

> a system of an adaptable modular grid with repetitive in-stock components . . . can gain both good design and the economy of bulk purchase and mass production (MAR 69-7).

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[7] Reference month and numbers at end of statement indicate source of quote, i.e.,(MAR 69-8) means document dated March, 1969, and listed in previous quote (No. 6) and, specifically, page 8 of the document.

Further,

> the use of materials which are brought to a near finished state at the factory may relieve pressures on the short local labor supply, and thus contribute toward timely completion of projects (MAR 69-5).

And . . .

> costs must be held below the current too high average for permanent construction (MAR 69-12).

From these goal statements one can summarize the following. The objectives of CSP were:

> TO REDUCE THE TIME REQUIRED TO PLAN AND CONSTRUCT NEW BUILDINGS AND ADDITIONS.
>
> TO REDUCE THE COST OF NEW BUILDINGS AND ADDITIONS (WHEN COMPARED WITH TRADITIONAL CONSTRUCTION).
>
> TO MAINTAIN OR IMPROVE THE QUALITY OF NEW BUILDINGS AND ADDITIONS.

In order to accomplish the goals and objectives, it was necessary to organize ideas, obtain support, and implement the ideas and concepts contained within the proposals.

Organizing to Accomplish the Goals

The initial commitment to the developers of the CSP required an adoption of the major concepts of the systems approach.

Concepts of Systemization

The concepts of the systems approach were basic to the CSP. Two major outcomes of systems application were considered essential to the success of CSP. These important concepts included (1) an effort to utilize industrial, standardized building components, and (2) to organize (schedule)

the planning-bidding and building activities along overlapping paths of action. These concepts can be explained more clearly by comparing the traditional pattern with the systems approach.

The traditional pattern of the construction industry has been that of individual design of building parts and great reliance on handicraft procedures. The resultant specialization of trades and the multiplicity of contractors has perpetuated and aggravated the problems of costs and delays. One principle of systemization is to take greater advantage of industrialization (off-site mass production) of precoordinated standardized construction components. A subsidiary concept has been to accomplish industrialization without standardization of overall design. Repetition of particular components, freely arranged within a grid system, has not been seen as seriously inhibiting the ability of different architects to solve creatively the space needs problems of individual schools and community groups.

The traditional pattern of most owners, such as boards of education, has been to establish a sequence of design development and documentation procedures in which each step is a cumulative advance toward the desired goal of a finished building. This process usually is interrupted by a multiplicity of reviews by the engineering disciplines, the owner representatives, the regulatory agencies, and others. Such linear sequencing tends to become overextended in duration. One result is that bid results are so far removed from the basic budget decisions, the owner loses a firm control of

costs. Therefore, another principle of systemization is to organize the total design-bid-build process for maximum concurrent action by all participants. The designers and builders are required to cooperate in scheduling their efforts, and the owner must cooperate in accelerated review decisions. It is assumed that the result will be better budgetary control, as well as faster building.

With these concepts developed into a proposal and with approval of the Detroit Board of Education, Educational Facilities Laboratories, Inc. was asked to join with the Board in cosponsorship of CSP.

Sponsorship of CSP

Most of the impetus for the development of the systems approach to building schools in the United States and Canada over the last decade stems directly from the interest and support of Educational Facilities Laboratories, Inc. (EFL) of New York. EFL was established by the Ford Foundation to encourage research and demonstrate creative planning in all aspects of educational facilities. Systems building has been only one of EFL's interests in upgrading school facilities, but it has been a fundamental concern because control of costs and construction time ultimately influences the accomplishment of other qualitative improvements in learning environments.

The Board of Education of the City of Detroit joined with EFL in sponsoring CSP. This cosponsorship involved the

provision of matching funds to establish and sustain the program with office space, staff, and consultants. In addition, the School Housing Division of the Detroit Public Schools provided a high degree of cooperation and administrative support. CSP is not a permanent department of the School Housing Division, but was created to be a developmental/demonstration project. As such, it was organized to provide research information (experience and data) that could be incorporated in the ongoing mainstream building program for the overall benefit of the Detroit Public Schools. As anticipated, the economies of a single demonstration project could justify the investment of the sponsoring agencies, quite apart from the sustained benefits of the empirical research.

Implementation of the Proposals

The initial proposal, jointly funded by the Detroit Board of Education and EFL in the spring of 1969, besides outlining the basic problems of high costs and slow construction time, focused on a particular need of the Detroit Public Schools for specialized-use space additions to secondary schools. It was recognized that the provision of such spaces (shops, laboratories, dining rooms, gymnasia, etc.) was far more complex technically than had been accomplished by other systems programs which focused on conventional academic classrooms. However, the need in Detroit was great. At that time, the proposal outlined a series of action stages, including a multiproject demonstration incorporating systems building

techniques (performance specifications, bulk bidding, phased bidding) planned to encourage speed and economy of industrialized construction. Specific projects were not identified.

In order to gain for the Detroit Public Schools the greatest possible expertise, CSP was organized under the overall guidance of an Advisory Committee comprised of twenty representatives of government, education, and the construction industry. The group has included several representatives from the two sponsoring agencies. The Advisory Committee, which met for the first time in September, 1969, has provided strong interest and generous help to CSP, and has done much to broaden the knowledge and perspective of the School Housing Division.

The CSP office opened in late October, 1969, and has functioned with a staff of two or three persons. In addition, to various studies of improved construction methods, the office has used a number of consultants (engineering, codes, cost, scheduling, educational, and systems planning) for recommendations, and has provided a forum for the necessary cooperation between participating architects and contractors. The initial proposal, jointly funded by EFL and the Detroit Board of Education, supported the CSP office through its first two years. A supplemental proposal, approved by the two sponsoring agencies in November, 1971, has assured a vigorous program at least through the balance of 1972. The supplementary proposal commits the program to an active role in

expanding and improving systemization in a second track program to be called CSP-2.

SECTION III

PROCEDURES AND MANAGEMENT OF CSP

The procedures adopted by a group to attain the organization's goals and objectives, coupled with the management decisions made at critical points, affect the outcome of a project. Certainly, the procedures adopted in the early stages of CSP relating to management control, advisory input, and the commitment to research and development were major influencing factors. In addition, decisions made relating to design, bidding, and building influenced CSP direction. A summary of major elements of the procedures and decisions follows.

Critical Procedures Establishing Program Direction

CSP program direction was influenced through the maintenance of centralized control of management decisions, diversified advisory capacity, and a commitment to research and development.

Centralized Control

The problems of fragmentation and specialization confronting the construction industry are nearly impossible to solve by individual architects, engineers, suppliers, or

contractors working independently. The portion of work controlled by each is so small that it precludes significant steps toward industrialization. Rather, the development of innovative building systems is most effectively accomplished by large owners generating the dollar volume market of multiple projects and maintaining control of the management of the projects. Even the samller building systems programs require a strong central organization to focus and control the overall design-bid-build sequence. For CSP, the control has been centered in the CSP Office, with direct administrative support from the School Housing Division.

Diversified Advice

Like most large institutions, the Detroit Public Schools have multiple hierarchical decision-making levels. In order to penetrate and diffuse information within such a complex structure and to bring nonvested contributions to bear on the CSP, a diversified advisory structure was developed. The CSP Advisory Committee was selected to accomplish these tasks. Not only does the Committee include statewide representation in the areas of government, education, and the construction industry, but its diversified experience has been augmented by meetings organized to provide a national view of building program planning methods. Additionally, the CSP Office has sought to expand its scope by extensive liaison with national manufacturers, contractors, and labor groups,

all of whom are essential segments of the total construction operation.

Research and Development

Intrinsic to the original proposal, "Supplementary School Space System," was a multiproject demonstration. A commitment had been made to explore a particularly difficult but badly needed building type (multistory, specialized-use additions to secondary schools). The procedural concept that transformed a demonstration into the present, more evolutionary research and development program came out of Advisory Committee recommendations. It is recognized that not all buildings or groups of buildings lend themselves to systemization. In any particular circumstance, there are conditions of schedule, the economy, industry capability, community concerns, etc., which would alter how a particular program is organized. The next section outlines some of the more significant decision points regarding CSP-1.

Management of CSP-1

Many management decisions affecting program direction were made. In general, these decisions centered on design, bidding, and building.

Design

Choosing Appropriate Project Size.--In a multiproject program, the total dollar volume should be of sufficient size to interest manufacturers of components. However, the bidding

packages should not be so large that they would deter participation by local contractors if, as is generally true, the owner is dependent on local labor sources.

Selecting Cooperative Design Professionals.--If projects are individually commissioned (as has been traditional with the Detroit Public Schools and most school owners), architects and engineers designated for participation in a systems program must adapt to new design parameters. Not only must they work within a dimensional grid or module, but they must cooperate with jointly developed budgeting and scheduling criteria. Most architects and engineers are not trained or experienced in these patterns, but an increasing number can understand the need for such cooperation and can appreciate the budgetary protection provided them by a joint effort. The four architects and their consulting engineers for CSP-1 have proven to be adaptable and cooperative.

Deciding to Borrow from a Predecessor Program.--Making changes in the construction industry can be expensive and time consuming. The research and development required for even minor changes can be prohibitive for an owner. Therefore, it is both necessary and logical that the various systems programs have evolved gradually, basing their changes to a considerable degree on the experience of prior programs. In the beginning stages of CSP, several earlier programs were analyzed. The one which seemed to have the greatest applicability for CSP-1 (one- and two-story specialized-use additions

to secondary schools) was the Metropolitan Toronto School Board's "Study of Educational Facilities" (SEF). The decision to borrow from Toronto has both influenced and benefited CSP design development.

Designating Subsystems.--The Toronto SEF program was a larger, more comprehensive, and more developed endeavor than Detroit could support at the time CSP was initiated. Just how much of the Toronto program was adaptable to Detroit needs was a question which had to be answered. For this purpose, CSP turned to Detroit consultants and to the commissioned architects. After analysis, the recommendation was to designate five subsystems (Structure, Atmosphere, Lighting-Ceiling, Interior Space Division, and Vertical Skin). In so doing, certain possible subsystems (Roofing, Electric-Electronic, Plumbing, Flooring, Cabinetry) were eliminated.

Bidding

Attracting Bidders.--In analyzing the management of predecessor systems programs in other parts of the country, the bidding patterns developed in the State of Florida's "Schoolhouse Systems Project" (SSP) appeared to be particularly successful in speed and economy. By balancing the off-site component fabrication (which attracts larger industrialized bidders) with the on-site local labor construction (which attracts local contractors), SSP has been able to maintain a very competitive market situation. Although the decision was to adopt a similar approach for CSP-1, it was

apparent that further effort was required when utilizing these techniques for the first time in Michigan. Therefore, great attention was given to developing the interest of national manufacturers.

Organizing for Phased Bids.--Phased bidding or "fast tracking" can be organized in a number of ways. Obviously, the lump sum general contractor bid reduces to a minimum the number of decisions an owner must make. However, there is great danger in finally exceeding the budget. In CSP-1, there were two principal bidding categories (subsystems and nonsystems). Additionally, certain on-site utilities work was bid prior to subsystems. Also, in order to expedite the projects, substructure work was extracted and separately bid prior to the balance of nonsystems. The desirable degree of "fast track" bidding overlap varies with the individual project characteristics and scheduling pressures. Including the substructure, approximately 49 per cent of the cost of the CSP-1 additions (exclusive of alterations) was bid and awarded while the architects were still working on contract documents for the balance of the work.

Controlling Costs.--Despite many other factors indicating an economic downturn, construction costs have continued to rise. Although CSP would not reverse the trend, its objective has been to hold the costs at or below prior levels. Most of the decisions made in CSP have, in one way or another, reflected this concern. The established mechanism of the School Housing Division, requiring periodic detailed cost

estimates from the architects, was augmented in CSP-1 by the use of a construction cost consultant, employed by the owner, who reviewed the documents at several critical points and who was an active participant in review of bids.

Awarding Contracts.--Nearly all of the techniques of cost control and project acceleration associated with systems building imply an active owner participation in management. Of particular urgency is the owner's ability to make rapid decisions. The CSP Advisory Committee heard of the success of other programs, and then compared these results with the traditional patterns in Detroit. Their conclusion was that the standard review-approval procedures in Detroit were too linear in nature and, thus, too extended in duration. The practice of delaying all contract awards until formal action by the Board of Education at an official meeting was viewed as unnecessarily time consuming. Therefore, the Committee recommended to the Board as follows:

> Resolved that the Board of Education, with the approval of the design manuals for the four projects in the pilot systems program, authorize the School Housing Division to take bids and award contracts within the stated budget allocations for the projects.

This action, unanimously approved by the Board on September 22, 1970, has greatly accelerated CSP-1 progress.

Building

Scheduling the Work.--Although the School Housing Division has extensive experience in utilizing computer-generated network scheduling techniques, the CSP endeavor

called for a new and special effort because of the multiple projects and the accelerated program. Beginning several months in advance of the subsystems bidding, a scheduling consultant was employed to oversee all time-sequence factors. His responsibilities included preparation of a master schedule and individual project schedules, both precontract and postcontract. The precontract portions outlined the owner's work, particularly for CSP staff, and the work of the architects and engineers. The postcontract portions pertained to both subsystems and nonsystems contractors' work. Essential to the effectiveness of this scheduling effort was the inclusion in the contract document of a penalty clause for failure to meet schedule objectives and an incentive clause for completion of work prior to the scheduled date. Those contractors failing to meet their objectives could be assessed "damages" of $300 per day. Those contractors completing their work prior to the scheduled date received rapid payment and a reduction of retainer. In this regard, project status monitoring, reporting, and updating are as important as the original construction logic. The monitoring has continued to demand intensive attention since the start of on-site construction, and has also involved off-site fabrication and delivery procedures.

Approving the Work.--In efforts to economize, accelerate, and simplify the overall construction process, owners are experimenting with various combinations of building team membership. Certain "design and build" or "turn key" package

operations have diminished or eliminated architect participation. CSP, however, has retained an active, responsible role for architects in programming and design. The architects' responsibilities, as outlined in the general conditions of the contract, have moved away from "supervision" toward "inspection." The architects have retained the construction phase responsibilities for approvals of shop drawings and material selections. Testing procedures are also under the architects' jurisdiction. Only the architect is authorized to approve deviations from contract documents, to issue certificates of payment, or to authorize final acceptance of a building. In the future, greater industrialization of the building process may further alter the architect's role in on-site supervision. Also, the use of performance-type specifications, whereby industry suggests technological innovation, may postpone certain aspects of engineering design. However, such a change does not alter or eliminate the need for expert professional approval at all critical phases of the construction operation.

Managing the Work.--When the CSP subsystems were bid, the specifications described a general contractor who would not only bid the schools on a group basis, but would also act "in a coordinative management capacity." Prior to awarding nonsystems contracts, the decision was made not to utilize a general contractor in the traditional role, but to employ a management contractor to handle on-site supervision, coordination, and expediting of the twelve prime contractors, all of

whom were to work on all four schools. The management contractor, who is paid on a professional fee basis, does no direct construction work and is relieved of the "risk capital" responsibilities usually carried by general contractors. As owners have sought to expedite construction by overlapping design-bid-build procedures, there has been a greater merging of building team personnel. In some instances, increased managerial responsibilities have been undertaken by architects; in other cases, by contractor organizations. For CSP, the management contract services have been limited because they commenced only with on-site construction, rather than involving the design phases. The services have not included scheduling, but they have included a limited authority for on-site field orders to accelerate critical work.

Handling Owner Responsibilities.--For CSP-1, supervisory responsibilities were shared between a management contractor and the CSP construction coordinator. The owner responsibilities have both changed and expanded as the owner has undertaken certain "risk capital" aspects. Therefore, in addition to the normal coordination of site clearance, furniture, equipment, and the regular processing of progress payments, bulletins, and change orders, the CSP Office has initiated a number of services--fences, guards, temporary heat, fire insurance, etc.--normally provided by a general contractor. This increased involvement has made the owner the leader of the building team, and has greatly broadened his knowledge of construction activities. It provides the

owner greater flexibility to modify expenditures through closer control, although it increases, to a degree, the owner's risk.

Selecting Consultants.--Implicit in the procedures for systems building programs is active participation by the owner. Few owners can maintain all the in-house expertise necessary to initiate and sustain such a technically complex endeavor. Therefore, it is vital to find both staff and consultants to undertake this work. For CSP-1, there were consultant activities in eight major categories: Systems Planning, Educational Planning, Mechanical Engineering, Electrical Engineering, Structural Engineering, Building Codes, Construction Cost, and Scheduling. All but the systems planning consultants were from the Detroit area, and were well-acquainted with local practices, standards, and codes.

SECTION IV

CSP-1--PROJECT OUTCOMES

The products of CSP-1 may be examined in relationship to the school buildings, as constructed, and the degree of attainment of CSP goals and objectives. The schools are easily described, but it is only partially possible to assess them from the educational viewpoint.[8] Section IV is designed to describe the projects and to assess the effectiveness of CSP in relationship to the time and cost objectives. In addition, a discussion of elements of quality is presented.

CSP-1 Schools

The CSP-1 construction project consists of large additions to four secondary schools--three junior high schools and one senior high school. Each of the additions contains specialized spaces, such as dining assembly, health and physical education, vocational, and fine arts. Regular

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[8] For description of planned utilization of buildings prior to occupancy, refer to: 1) Report of Recommended Educational Specifications (prepared by Planning & Building Studies Department) and 2) Design Manual (prepared by the architect) for each of the CSP-1 projects. Also see Dr. James Neubacher, "Report on the Potential for Educational Program Upgrading Through Systems Construction," July, 1970.

academic classrooms are not included. A brief, general description of each school in the project follows.

Boynton School, located in the far southwestern corner of Detroit, was built in 1925 as a township K-8 elementary school. It became part of the Detroit Public Schools a few years later, when the township was annexed to the city. As part of the CSP-1 project, Boynton is receiving an addition of 54,625 square feet, and is being converted to a junior high school with capacity for 990 students.

Cerveny School, located in Northwest Detroit, was built in 1923 as a township K-8 elementary school. It received additions in 1929 and 1930, after becoming a part of the Detroit Public School system. At present, Cerveny is receiving an addition of 74,600 square feet, and is being converted to a junior high school with capacity for 1,200 students.

Cooley High School, located in Northwest Detroit, was built in 1927 and received major additions in 1929 and 1930. With the present addition of 105,000 square feet, Cooley will be a complete comprehensive high school with capacity for 3,250 students.

Sherrard Junior High School, located in the northern sector of Detroit's inner city, was built in 1923 to house approximately 700 students. With the present addition of 44,000 square feet, Sherrard will have capacity for 1,200 students.

CSP-1 Objectives

The objectives stated earlier in the report are repeated for the convenience of the reader. The objectives were:

> TO REDUCE THE TIME REQUIRED TO PLAN AND CONSTRUCT NEW BUILDINGS AND ADDITIONS.
>
> TO REDUCE THE COSTS OF NEW BUILDINGS AND ADDITIONS (WHEN COMPARED WITH TRADITIONAL CONSTRUCTION).
>
> TO MAINTAIN OR IMPROVE THE QUALITY OF NEW BUILDINGS AND ADDITIONS.

Reducing Time as a CSP-1 Objective

The first stated objective related to time of construction. At the time the design manuals were accepted, a schedule was outlined which included a twelve-month construction period.[9] Construction contracts for all four additions were awarded in May of 1971. Thus the target for completion of each project was May, 1972. Table 1 shows the award of contract, completion target date, essential completion date, and construction time for each project. Essential completion of the additions occurred in July and August, 1972, which was two to three months beyond the target. However, the stated objective was to reduce the time of construction. In other words, the CSP-1 buildings should be compared

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[9] Design manuals--Boynton, Cerveny, Cooley, and Sherrard.

with conventional building projects. In order to make such a comparison, five traditional building projects were selected for study. All of the projects were additions to secondary schools and are comparable in size and scope to the CSP-1 additions.

TABLE 1.--CSP-1 Time Chart.

School	Award of Contract for Foundations	Completion Target	Essential Completion	Construction Time
Boynton	5/1971	5/1972	7/1972	14 months
Cerveny	5/1971	5/1972	7/1972	14 months
Cooley	5/1971	5/1972	8/1972	15 months
Sherrard	5/1971	5/1972	7/1972	14 months
			(Average const. time	14.2 mo.)

The traditional schools construction data are found in Table 2. In each case, the projects took longer to build than anticipated. The smallest overrun is one month, and the longest is eight months. Much more important than the attainment of the target completion date is the total construction time. The range of construction time is from twenty-one months to thirty-two months, with an average construction time of 24.4 months. When compared with the average construction time of 14.2 months for CSP-1 schools, the difference of 10.2 months is significant.

TABLE 2.--Conventional Construction Time Chart.

School	Award of Contract	Completion Target	Completion	Construction Time[a]
Southwestern	1/1968	1/1970	9/1970	32 months
Longfellow	9/1968	9/1970	11/1970	26 months
Winterhalter	3/1969	9/1970	1/1971	22 months
Farwell	4/1970	12/1971	1/1972	21 months
Finney	4/1970	8/1971	1/1972	21 months
			(Average const. time	24.4 mo.)

[a]Award of contracts to effective occupancy of additions.

Reduction of Cost as a CSP-1 Objective

The second stated objective related to the reduction of costs. Data reflecting costs for the CSP-1 buildings are included in Table 3. Three of the additions (Boynton, Sherrard, and Cooley) had construction costs higher than the estimated construction costs, and one building (Cerveny) had construction costs lower than the estimate. The average construction cost was above the estimated cost by $.95 per square foot. The CSP-1 objective was to reduct the costs for construction and, in order to measure progress toward the cost objective, an analysis of the costs of traditional projects was made. The same projects used in the "time" comparison were used in the cost comparison. Table 4 contains data pertaining to the estimated costs, the actual construction costs, and adjusted costs that update the construction costs to the CSP-1 building time period. Adjusted construction

costs are based on cost factors from the Engineering News Record index, a nationally accepted source for construction cost indexes. It is worthy of notice that other nationally known indexes project even higher figures.

TABLE 3.--The CSP-1 Project (1971): Square Foot Cost for Construction (Architectural, Mechanical, and Electrical).

School	Square Feet	Estimated Cost Per Square Foot[a]	Construction Cost Per Square Foot[b]
Boynton	54,625	$30.65	$32.32
Cerveny	74,600	30.28	28.45
Cooley	105,179	29.23	31.25
Sherrard	44,000	30.00	31.94
Averages		30.04	30.99

[a]Design Manuals--Boynton, Cerveny, Cooley, Sherrard.

[b]Detroit School Construction Cost Analysis to 1971 (Chart #4 - CSP-1 Projects).

TABLE 4.--Conventional Projects (1968-1970): Square Foot Cost for Construction (Architectural, Mechanical, and Electrical).

School	Square Feet	Estimated Cost Per Square Foot[a]	Construction Cost Per Square Foot[b]	Adjusted Construction Costs[c]
Southwestern	90,689	$24.92	$27.90	$38.40
Longfellow	92,000	21.46	26.76	35.30
Winterhalter	65,360	25.85	29.05	36.50
Farwell	80,572	29.41	30.29	35.20
Finney	89,346	32.00	36.38	42.60
Averages		26.73	30.08	37.60

[a]Design Manuals--Southwestern, Longfellow, Winterhalter, Farwell, and Finney.

[b]Detroit School Construction Costs Analysis to 1971 (Chart #3 - Secondary Schools), project comparison sheets.

[c]Based on Engineering News Record "Building Cost Index" updated to July, 1971, bid date of CSP-1 nonsystems work.

The estimates of costs in the CSP-1 buildings were more accurate than estimates of costs for the conventional buildings. The average difference between estimates and actual costs for the CSP-1 buildings was $.95 a square foot, while the average difference between estimates and actual costs for the conventional buildings was $3.35 a square foot. Even more important, the average construction cost per square foot of $30.99 (Table 3), when compared with the average adjusted construction cost (Table 4) of $37.60 a square foot, indicates a significant cost savings of $6.61 per square foot.

Maintenance or Improvement of Quality as a CSP Objective

In the beginning of Section IV, it was stated that the objectives relating to time and costs could be measured in a fairly effective manner. However, the objective relating to quality is much more difficult to assess, for at least three reasons. First, the CSP-1 additions have just been occupied and their educational functions cannot yet be fully examined in use. Second, a measurement in terms of maintenance can be precise only when made over a period of time. Third, it is very difficult to establish a definition of quality that is acceptable to all the publics that use and evaluate the public schools. However, if one examines potential environmental qualities that are inherent in the design of the CSP-1 buildings, it is evident that the educational space will equal in environmental quality or be better than that now provided in conventional buildings. The design of space in the CSP-1

buildings will provide for flexibility, air conditioning, sound control, and photometric standards to meet the requirements of the highest quality learning environment. Although it is difficult to assess quality in buildings not yet fully utilized, it is easy to assess quality in predecessor programs, such as those buildings completed and in use in Toronto. The systems buildings in Toronto, from which Detroit borrowed elements, have been evaluated as excellent educational facilities. Thus, one could conclude that similar experiences will occur as Detroit educators and children begin to use the CSP-1 facilities.